REMARKS

Claims 1-19 and 21-67 are all the claims pending in the application. Claim 20 has been canceled without prejudice or disclaimer. Reconsideration and allowance of all the claims are respectfully requested in view of the following remarks.

Claim Rejections - 35 U.S.C. § 112

The Examiner rejected claims 40-42 because "the elastic film" lacks sufficient antecedent basis. Applicants have amended claims 40-42 to depend from claim 10, wherein an elastic film is set forth, instead of from claim 1.

Claim Rejections - 35 U.S.C. § 102

The Examiner rejected claims 1-3, 10, 20-22, 36, 40-42, 48, 51/1-3, 51/10, 51/48, 52/1-3, 52/10, 52/48, and 67, under §102(b) as being anticipated by EP 0 786 345 to Hashizumi et al. (hereinafter Hashizumi). Applicants respectfully traverse this rejection for at least the following five reasons.

1. Hashizumi fails to disclose all the elements as set forth in the claims

Claim 1 sets forth an ink jet recording head of the type having a diaphragm, and a piezoelectric element on the diaphragm, the piezoelectric element having at least a lower electrode, a piezoelectric layer, and an upper electrode, the improvement comprising at least one of the group consisting of a diaphragm and a piezoelectric element includes a compression film having a compressive stress, wherein at least a part of a thickness of the compression film is removed in an area opposed to the pressure generation chamber, and further wherein the lower electrode includes a tensile stress.

For example, as shown in Fig. 6c, one embodiment of the present invention is in an ink jet recording head of the type having a diaphragm 50, and a piezoelectric element 300 on the diaphragm, the piezoelectric element having at least a lower electrode 60, a piezoelectric layer 70, and an upper electrode 80, the improvement comprising the diaphragm 50 includes a

compression film having a compressive stress, wherein at least a part of a thickness of the compression film is removed in an area 350 opposed to the pressure generation chamber 12.

The present application is directed to an ink jet recording head wherein some of the pressure generation chambers, communicating with nozzle openings for jetting ink drops, are formed of a diaphragm and a surface of the diaphragm is formed with a piezoelectric element for jetting ink drops by displacement of the piezoelectric element and, accordingly, the diaphragm.[1]

In this type of record head, the piezoelectric element acts in a deflection vibration mode to put pressure on the diaphragm to squeeze ink out of the ink chamber and through the nozzle onto the recording medium.[2] However, in the previously known thin film patterning methods for forming the diaphragm, piezoelectric member, and pressure chambers, the diaphragm was initially deflected to the pressure chamber side by the force f, which is the effect of the internal stresses of the films. See Figs. 7(b), 8(b), and the specification at the paragraph bridging pages 1 and 2. With such an arrangement, the diaphragm is subject to a possible plastic deformation when an additional force F is applied to the diaphragm by the piezoelectric element. See, again, Fig. 8(b). And if the diaphragm undergoes plastic deformation, thereafter it will not function effectively to jet ink from the nozzle with which it is associated.

It is thus an object to provide an ink jet recording head with a decreased amount of initial deflection.[3] Embodiments of the present invention achieve this reduced diaphragm-initial-deflection by providing at least one of the diaphragm and the piezoelectric element with a compression film 50 having a compressive stress σ_4, wherein at least a part of a thickness of the compression film 50 is removed in an area opposed to the pressure generation chamber 12, thereby forming a removal part 350. The specification describes one manner in which the compression

[1] Specification at page 1, 1st full paragraph.

[2] Specification at page 1, 2nd, and 4th to 6th paragraphs.

[3] Specification at page 2, 1st to 3rd full paragraphs.

film—having a compressive stress—is formed. See, for example, page 13, 3rd full paragraph to page 15 last full paragraph. Although the process for making the diaphragm and piezoelectric element are not a part of the presently claimed invention, an understanding thereof helps one to understand the present invention. Thus, as shown in Figs. 6(a) - 6(c), because the compressive stress σ_4 in the elastic film 50 is made to balance—via formation of removal part 350—the stresses σ_1-σ_3 in the elements 60, 70, 80, of the piezoelectric element 300, the initial deformation of the diaphragm is greatly reduced, or eliminated, when the pressure generation chamber 12 is formed. Accordingly, as shown in Fig. 8(a), when deformation force F is applied to the diaphragm to jet ink, the diaphragm desirably remains in its elastic deformation area. See, also, page 16, 3rd full paragraph, as well as the paragraph bridging pages 16 and page 17.

In contrast to that set forth in claim 1, Hashizumi fails to disclose a compression film having a part thereof removed in an area opposed to a pressure generation chamber, and also fails to disclose a lower electrode including a tensile stress.

The Examiner relies on Hashizumi's Figs. 12 and 15 as disclosing this feature.[4] The Examiner's interpretation of Hashizumi is mistaken. Actually, Hashizumi discloses layer BE may have such a thickness so as to balance the internal compression stress in layer VP. That is, it is layer VP that has an internal compression stress. But layer VP does not have a part thereof in the thickness direction removed in an area opposed to the pressure generation chamber IT. Instead, it is layer BE that has a part thereof removed in the area of the pressure generation chamber IT. Yet layer BE is not disclosed as having an internal compression stress.

Further, for the sake of argument, Hashizumi's Fig. 15 shows a portion of the layer VP removed in the area of the pressure generation chamber IT. However, in connection with Fig. 15, Hashizumi does not disclose that the layer VP has an internal compression stress. And Figs. 12 and 15 disclose different embodiments to which different considerations may apply. For

[4] Office Action at the paragraph bridging pages 2-3.

example, Hashizumi specifically states that in the Fig. 12 embodiment, the layer BE is used to balance the compressive stress in the layer VP, and that in order to do so the thickness ta2 in the layer BE is 200 nm or more. See Hashizumi at col. 10, lines 5-9. In contrast, in the Fig. 15 embodiment, the thickness ta2 in the layer BE is **zero**. Accordingly, because the Fig. 15 embodiment includes no balance for any compressive stress in the layer VP, the layer VP likely has no compressive stress.

In light of the above, Hashizumi does not disclose a compression film having a compressive stress, wherein at least a part of a thickness of the compression film is removed in an area opposed to the pressure generation chamber, as set forth in claim 1. Further, Hashizumi fails to disclose any tensile stress in the layer BE that the Examiner relies on as a lower electrode. Accordingly, Hashizumi fails to anticipate claim 1. Likewise, this reference fails to anticipate dependent claims 2, 3, 10, 21-22, 36, 40-42, 48, 51/1-3, 51/10, 51/48, 52/1-3, 52/10, 52/48, and 67. Nonetheless, Applicants respectfully traverse this rejection as it applies to claims 3, 4,, 24, 41, 53, and 55, for the following additional reasons.

Claims 3 and 41 each set forth that the compression film has at least a part in the thickness direction removed only in a portion along margins of the pressure generation chamber. For example, as shown in Fig. 13b, one embodiment of the present invention comprises a compression film 50 having a removal part 350 that exists only in a portion along margins of the pressure generation chamber 12.

The Examiner cites Hashizumi's Fig. 15 as showing this feature. The Examiner's interpretation of Hashizumi is mistaken. Instead, Hashizumi discloses that the lower electrode BE (Fig. 12), or the diaphragm VP (Fig. 15), are removed not only in the margins of the pressure generation chamber IT, but also in the areas extending to the right-most and left-most portions of the figures, wherein the removed part extends over a substantial area of SI where there is no pressure generation chamber. Accordingly, Hashizumi fails to anticipate claim 3 or claim 41.

2. The Examiner's Interpretation of Hashizumi is mistaken

The Examiner relies on col. 16, lines 20-25 in asserting that the layer VP in Fig. 15 and the layer VP in Fig. 12 are formed by the same processes, are made of the same material, and on the same substrate and, therefore must have the same characteristic properties.[5] Applicants disagree for at least the following reasons.

The layers VP in Figs. 15 and 12 are not necessarily made by exactly the same processes and under the same conditions and, therefore, do not necessarily have the same properties.

Instead, in col. 16, on the lines relied upon by the Examiner, Hashizumi states that in the Fig. 15 "embodiment, the same steps as those previously described with reference to Figs. 16-26 are executed." But the "steps" as described with reference to Figs. 16-26, are very general in nature and include a considerable amount of variability. For example, in connection with the layer VP, Hashizumi discusses one particular embodiment in col. 12, lines 47-54, and then states that the "film formation method is not limited to it and the thermal oxide film may be, for example, a silicon oxide film formed by wet oxidation or a silicon oxide film formed by a reduced pressure chemical vapor phase growth method, an atmospheric pressure chemical vapor phase growth method, or an electron cyclotron resonance chemical vapor phase growth method."[6] And the existence, as well as type, of stress is highly dependent upon the manner in which the film is made as well as on the annealing processes to which it is subject.

The present specification indicates that the compressive stress is achieved via specific processing steps. For example, when the compression film forms the elastic film 50, a zirconium layer is formed on the substrate by sputtering, and then thermal oxidation processing occurs in oxygen at a high temperature to achieve a monoclinic system. During oxidation, the zirconium is heated to a phase transition temperature or more. Therefore, when cooled, a transition occurs

[5] Office Action at page 7, 2nd paragraph.

[6] Hashizumi at col. 12, line 54 - col. 13, line 2.

resulting in the zirconium oxide having a compressive stress.[7] The specification also provides the processing details to achieve the compressive stress when the compression film forms other layers in the ink jet recording head.[8]

By sharp contrast to the presently claimed invention, Hashizumi does not describe how any specific processing steps would lead to a compressive stress in the relied upon layers. Rather, Hashizumi merely indicates the locations of these layers, their respective functions, and exemplary materials that may be used to form the layers. Thus, at best, Hashizumi is ambiguous as to whether the Fig. 15 layer VP includes an internal compressive stress. And any ambiguity of the reference should be construed against the Examiner. See *In re Robertson*, 49 U.S.P.Q.2d 1949 (Fed. Cir. 1999).

Additionally, Applicants have submitted articles showing that compressive stress is highly dependent upon the manner of processing a material.

Although some materials exhibit compressive stress, other materials exhibit tensile stress, whereas still others exhibit no internal stress; all stress is not compressive. Note Figs. 1a and 1b in the article by B. Stein entitled "A Practical Guide to Understanding, Measuring and Controlling Stress in Electroformed Metals", submitted with the January 10, 2002 Amendment.[9] Further, as noted in the article entitled "Applications" by the Residual Stress User Center—also submitted with the January 10, 2002 Amendment[10]—residual stresses originate from differential plastic flow, differential cooling rates, or phase transformations with volume changes. These stresses can be created by welding, forging, casting, rolling, machining, surface treatments, or

---

[7] Specification, paragraph bridging p. 13-14.

[8] When the compression film forms the lower electrode 60, <u>see</u> p. 21, 1st paragraph. When the compression film forms the upper electrode 80, <u>see</u> p. 22, 5th and 6th paragraphs.

[9] This article is again submitted herewith for the Examiner's convenience.

[10] This article is also submitted again herewith for the Examiner's convenience.

heat treating.[11] And stresses that develop in composites primarily result from differences in the respective thermal expansion coefficients.[12]

As further evidence that not all films include a compressive stress, and that the stress is highly dependent upon processing, Applicants submitted, with the March 10, 2003 Response, an article entitled "Stresses in Pt/Pb(ZrTi)O_3/Pt thin-film stacks for integrated ferroelectric capacitors", by G.A.C.M. Spierings et al., Journal of Applied Physics, vol. 78 (3), August 1, 1995, pp. 1926-1933 (hereinafter Spierings).[13]

Spierings teaches that several different stresses, such as intrinsic stress and thermal stress, can be present in a thin film. Spierings goes on to teach that the magnitude of the intrinsic stress is largely determined by the deposition conditions—i.e., how the film was made—and change upon annealing. See, for example, page 1927, right column, 1st full paragraph to page 1928, end of left column. Additionally, with respect to the platinum bottom electrode, Spierings specifically teaches that the "stress in a sputtered metal film can be varied over a wide range, from tensile to compressive, by modifying sputter conditions such as pressure and power."[14] Further, with respect to the stresses in the PZT film, Spierings teaches that a first PZT layer is compressive, whereas two subsequent layers are increasingly tensile.[15] Moreover, Spierings teaches that the stresses in each of the electrodes and PZT film changed from compressive to tensile, or vise versa, upon annealing. See, for example, Table III, and the paragraph bridging pages 1930-1931. Also, see section VI. Discussion and Conclusions on pages 1932-1933.

---

[11] See "Applications" at page 1, 1st paragraph.

[12] See "Applications" at page 1, 2nd paragraph.

[13] A copy of Spierings is submitted herewith for the Examiner's convenience.

[14] Spierings at page 1928, right column, paragraph carrying over to page 1929.

[15] Spierings at page 1929, right column, last paragraph, carrying over to page 1930.

In light of the above, Applicants have shown that it is readily known within the skill of the art that not all materials include a compressive stress, and that the stress profile of a material depends upon how it was made, and to what annealing treatments it was subjected.

Accordingly, because Hashizumi's embodiments of Figs. 12 and 15 are not necessarily made according to exactly the same processes, they do not necessarily include the same properties, i.e., condition of internal stress.

Further, Hashizumi specifically discusses the internal stresses of layer VP when discussing the embodiment of Fig. 12, whereas he is notably silent as to any internal stressing in the layer VP when discussing the embodiment of Fig. 15. Compare Hashizumi at col. 8, line 29 - col. 10, line 11 with col. 16, line 21 - col. 17, line 18. Moreover, Hashizumi fails to identify what processes lead to the compressive stress in Fig. 12, let alone that those same processes are used in the Fig. 15 embodiment.

In light of the above, it cannot be said that the Fig. 15 embodiment "must" include a compressive stress, as is necessary to meet the Examiner's claim that this embodiment "inherently" includes a compressive stress as does the disparate embodiment discussed in connection with Fig. 12.

In contrast to that in Hashizumi as relied upon by the Examiner, the present invention is characterized by a feature in which a film having a compressive stress is removed at a certain location to cancel (or release) a residual stress to thereby avoid the undesired deformation of the film and improve the performance of the piezoelectric element. See, for example, the second paragraph of page 15 in the present specification.

3. Hashizumi's Fig. 12 and Fig. 15 embodiments don't have the same characteristics

Again, Hashizumi specifically states that in the Fig. 12 embodiment, the layer BE is used to balance the compressive stress in the layer VP, and that in order to do so the thickness ta2 in the layer BE is 200 nm or more. See Hashizumi at col. 10, lines 5-9. In contrast, in the Fig. 15 embodiment, the thickness ta2 in the layer BE is **zero**. Accordingly, because the Fig. 15

embodiment includes no balance for any compressive stress in the layer VP, the layer VP likely has no compressive stress.

4. The Examiner's reliance on MPEP 2145 (I) is misplaced

The Examiner asserts that Applicants' assertions are "just attorney argument statements and not the kind of factual evidence to show that the VP layers in Fig. 12 and Fig. 15 can not be made by the same process." Office action at page 7, lines 4-8. However, MPEP §2145 points to MPEP §716.01(c) for a definition of what attorney statements that must be supported by an affidavit. And MPEP §716.01(c) sets forth that "evidence of unexpected results, commercial success, solution of a long-felt need, inoperability of the prior art, invention before the date of the reference, and allegations that the author(s) of the prior art derived the disclosed subject matter from the applicant" must be supported by an affidavit. In contrast, in the present case, Applicants' arguments are directed to the interpretation of Hashizumi and, as such, are entitled to full consideration without necessity of an affidavit or declaration. Further, Applicants have explained in great detail above, using articles as supporting evidence, why the VP layers in Hashizumi's different embodiments do not necessarily include the same characteristics.

It is Applicants' argument that the layers in Hashizumi's Figs. 12 and 15 are not made by the exact same processes. As further evidence of this assertion, Applicants note that the Fig. 15 embodiment is subject to more processing than is the Fig. 12 embodiment at least in that the Fig. 15 embodiment requires removal of all thickness ta2 in the layer BE, and removal of the layer VP to a depth of td2. And this additional processing, i.e., removal of layer VP, will alter its characteristics. Accordingly, because the configurations of the Fig. 12 and Fig. 15 embodiments are different, their layers VP do not necessarily have the same characteristic properties, as inaccurately asserted by the Examiner. See the Office Action at page 7, lines 8-13.

5. The Examiner's attempted definition of compressive stress is misguided

In the paragraph bridging pages 7 and 8, the Examiner attempts to define "compressive stress". Instead, the Examiner sets forth something more closely related to a material's modulus

of elasticity. That is, to a certain extent (the elastic limit), all materials have the ability to withstand some load or resist distorting effects of an external force or load. Thus, the material may distort when holding the load, and then returns to its original shape when the load is removed. But such a property (elasticity) is different from "internal compressive stress". As noted above in the articles to Stein, the Residual Stress User Center, and Spierings, not all materials have an "internal compressive stress", and the "internal stress" of a material can vary greatly even though the material still has the ability to resist distortion. Thus, although all material can withstand an external load, not all have an internal compressive stress. And as noted in the specification, it is Applicants who have discovered that by advantageously using a "internal compressive stress", the diaphragm can **better** withstand the loads placed on it without bending beyond its elastic limit.

6. Conclusion

For at least any of the above reasons, Hashizumi fails to anticipate Applicants' claim 1. Likewise, this reference fails to anticipate the dependent claims 2, 3, 10, 21-22, 36, 40-42, 48, 51/1-3, 51/10, 51/48, 52/1-3, 52/10, 52/48, and 67.

<u>Claim Rejections - 35 U.S.C. § 103</u>

- The Examiner rejected claims 11, 12, 51/11-12, and 52/11-12, under §103(a) as being unpatentable over Hashizumi in view of US Patent 6,022,458 to Ichikawa (hereinafter Ichikawa). Applicants respectfully traverse this rejection.

As noted above, Hashizumi is deficient. Ichikawa fails to teach or suggest anything that would cure the above-noted deficiencies in Hashizumi. Accordingly, even assuming that the Examiner was motivated to combine the references as suggested by the Examiner, any such combination would still not render obvious Applicants' claims 11, 12, 51/11-12, and 52/11-12.

- The Examiner rejected claims 23, 38, 51/23, 51/38, 52/23, and 52/38, under §103(a) as being unpatentable over Hashizumi in view of US Patent 5,831,299 to Yokoyama (hereinafter Yokoyama). Applicants respectfully traverse this rejection.

As noted above, Hashizumi is deficient. Yokoyama fails to teach or suggest anything that would cure the above-noted deficiencies in Hashizumi. Accordingly, even assuming that the Examiner was motivated to combine the references as suggested by the Examiner, any such combination would still not render obvious Applicants' claims 23, 38, 51/23, 51/38, 52/23, and 52/38.

Conclusion

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

Jeffrey A. Schmidt
Registration No. 41,574

SUGHRUE MION, PLLC
Telephone: (202) 293-7060
Facsimile: (202) 293-7860

WASHINGTON OFFICE
23373
CUSTOMER NUMBER

Date: August 29, 2005